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The Mono corer : a wide diameter, general purpose, gravity coring tool.

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THESIS

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ABSTRACT

Many gravity corers in use today exhibit inherent problems and shortcomings associated with their design. The "MONO" corer is a wide diameter, general purpose, gravity coring tool designed to help alleviate some of these shortcomings. It incorporates several unique features so as to enable coring operations to be carried out with increased reliability and efficiency. Among these features are:

a. A quick method of attaching the core cutter to the core barrel.
b. Quick-action clamps used to attach the lower and upper sections of the corer.
c. A streamlined weightstand which encloses the weight and streamlines the corer, thus offering less drag.
d. A large-area water vent assembly which prevents a pressure buildup above the core.

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ACKNOWLEDGMENTS

The author wishes to thank Dr. R. J. Smith for his assistance in the development of this coring device, and Mr. John Moulten for his aid in constructing the instrument. In addition, the time provided by Dr. E. L. Hamilton, Dr. R. F. Dill, Mr. N. F. Marshall, and Mr. A. L. Inderbitzen proved invaluable, and appreciation is expressed here.

CHAPTER I

INTRODUCTION

A gravity corer in its simplest form consists of a tube with a check-valve at the upper end which is driven into the sediment by encircling weights in order to obtain a sample. Credit for the invention of the gravity corer has been given to Henry Marc Brunel, who used one in 1866 for a marine geological survey of the floor of the Straits of Dover (Donovan, 1967). His device consisted of a "punch lead", which was a sounding lead with a small sampling tube fixed to its lower end. The *Challenger* Expedition in 1878 used the "Hydra" corer consisting of a brass tube encircled by detachable weights with a butterfly valve located at the lower end of the tube (Hopkins, 1964). This valve was the first attempt to use a core retainer. The cores obtained were quite short and were cut in half vertically by the butterfly valve, thereby producing considerable disturbance of the sample. Although not overly desirable, the "Hydra" corer remained in use until 1905 when Ekman developed a corer which was to be the prototype for later samplers. His device consisted of a steel tube with a stationary lead weight near its upper end and with fins located above the weight to stabilize it during descent. The tube had a check-valve at the upper end, and a pair of jaws which closed over the lower end after a core was taken. Cores up to two meters long were obtained with the Ekman corer, however there was a great distortion of the sample due to compaction (Hopkins, 1964).

The "Albatross" corer was designed in 1914 in an attempt to eliminate the principle difficulties with the Ekman device; the brass jaws which caused sediment distortion, and the instability of the weight. It was

made up of two sections which were coupled together. The lower section consisted of two concentric brass tubes arranged with lead between them in order to lower the center of gravity. At the lower end was a stopcock which was closed by the increased tension of the hoisting line as the corer was being pulled from the sediment. The problem of compaction and disturbance, however, was still a major one (Hopkins, 1964).

Although many varieties of corers were designed in the ensuing years, no significant improvements were made until 1941 when the Emery-Dietz corer was introduced (Emery and Dietz, 1941). The major contribution of this instrument was an improved core retainer. A nosepiece of a smaller diameter than the coring tube was screwed into the bottom end of the barrel. Plastic strips which bent inward toward the center of the tube were fitted into the nosepiece and served to retain the core. This retaining device was the prototype for the spring-leaf type core retainers in use today.

In 1949, M. J. Hvorslev published an extensive document on exploration and sampling subsurface soils, in which he proposed a method for minimizing disturbances of sediment samples by reducing the inside and outside friction of the coring tube. This method entailed making the inside and outside diameter of the cutting head larger than those of the coring tube, but not so much larger that a blunt surface would be required to penetrate the sediment. In addition, a complete study of the important factors to consider in all types of coring operations was presented, thus paving the way for more efficient corers to be designed.

The most widely used gravity corer is the Phleger corer (Hopkins, 1964). It is a small instrument having a weighted tube, a removable liner, a replaceable cutting head, and a spring-leaf type core retainer. It is very reliable in operation, though it can only take short cores.

Many unique devices ranging from Iselin's square corer (Hopkins, 1964),

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to the Boomerang corer (Raymond and Sachs, 1965) have been developed in an effort to secure better sediment samples. Even with the advances made in the field of coring, many problems still exist which prevent obtaining needed information and data.

Problems Associated with Existing Corers

The present day coring devices have become more sophisticated in their design and use, and in general tend toward the obtaining of longer cores. Such devices include the many varieties of piston corers, vibratory corers, box corers, and corers having an external driving source. Included among these are intricate designs which attempt to provide longer and larger diameter samples having less sediment disturbance, greater recovery ratios, and larger volumes of sample. Some of these new features are externally activated watertight core retainers (Kermabon, Blavier, Cortis, and Delauze, 1966), sliding weights (Rosfelder and Marshall, 1967), jetting of water over the core barrel (Coffee, 1968), and core conveyors (Kjellman, Kallstenius, and Wagner, 1950). The operating principles of these and other innovations in the field of coring are basically sound, but are relatively untested in field operations and have two major disadvantages. The first of these is that as the basic coring tube is modified by the addition of new features it becomes larger and heavier and hence more difficult to handle. The second disadvantage is that the more intricate a coring device becomes, the less likely it is to function properly during every coring operation. The reliability of the tool is therefore decreased. While coring devices have become larger and heavier in order to provide a suitable base for the attachment of new features, the cores obtained have not become proportionately larger, thicker, or less disturbed.

In many phases of marine geological research, such drawbacks can and

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must be tolerated at the present time, in the interest of advancing our knowledge of the geological character of the ocean floor, the overriding consideration in this case being that any cores obtained are better than none at all. However, these are many other existing situations in which efficiency and reliability are necessary prerequisites before a coring operation can be undertaken. In the future, many of the prototype devices mentioned previously will be sufficiently perfected and able to be used with a high degree of reliability and efficiency, but the state of the art at the present time is such that they cannot be economically employed.

Requirements for Study

At many oceanographic institutions where a variety of research is undertaken relative to the ocean bottom, an efficient and reliable general purpose coring device is required. Such a device should enable the biologist, geologist, sedimentologist, or engineer to obtain a sample which meets his particular requirements. A simple gravity corer fits many of these needs. In addition to being reliable, it is easy to handle and operate.

The gravity corers in use at the present time have not significantly changed from the earlier corers. Even the most reliable of gravity corers are not without some drawbacks. The Phleger corer, for example, although light, reliable, and easy to operate is much too small to be of use in fulfilling the needs of many marine geological surveys. Larger versions of the Phleger corer have been built, and although providing larger cores, they are difficult to handle aboard ship. A major problem concerns the methods of assembly and disassembly of the various components. In many models the core barrel may be up to ten feet long and is screwed into the upper section of the corer, and the core cutter is either screwed to the lower section of the barrel or is attached by use of set screws.

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In order to obtain the core, the core barrel and core cutter must first be removed. Unscrewing a core barrel which is wet and covered with sediment becomes a difficult task at sea because it must be handled carefully in order that the sample not be disturbed. Shaking or jarring of the barrel can sometimes distort the sample so as to make it useless for many purposes. Removal of a core cutter screwed onto the barrel is also hampered by sediment clinging to the outside. In addition, threaded joints have a tendency to distort upon receiving a heavy blow as in striking the bottom, thereby making it very difficult to remove. The use of set screws is a disadvantage in that the screws are small and are easily lost, and also tend to be readily stripped or sheared.

Most large gravity corers have detachable weights in order that the load may be varied to help control penetration. Methods have been devised to lock these weights to each other and to the corer, but rough handling both aboard ship and on the ocean floor may cause them to come loose and be lost. Also, the weights are frequently designed with a flat lower surface, thus creating a large drag on the corer as it is lowered through the water.

The above represents but a few of the problems associated with gravity corers. An attempt is made herein to solve some of these problems and produce a reliable, easy to handle, general purpose, gravity coring tool useful for all phases of oceanographic research.

CHAPTER II

DESIGN CONSIDERATIONS

The following presents the important factors to be considered in designing a sediment sampler in order to explain the reasoning behind the ultimate design of the "MONO" corer. The overall design of the unit is considered, as well as the design of the individual components.

Overall Design

A gravity corer can range in complexity from a simple weighted tube to a very intricate instrument where combined actions of lowering and retrieving the corer activate or trip various mechanisms in an attempt to secure a better sample. The following criteria are some that should be met in designing a coring instrument:

a. The sampler should have a minimum number of working parts.
b. The material used in building the instrument, particularly that used in the working parts, should be corrosion resistant.
c. The instrument should be sturdy enough to endure repeated handling on deck and contact with the bottom.
d. The size and weight of the instrument should be such that it is not overly difficult to handle on deck.
e. The instrument should orient correctly before contact with the bottom.
f. The instrument should have sufficient weight or power supplied to it to get the required penetration into the sediment.
g. There should be little disturbance of the sediment sample during penetration and withdrawal of the instrument.
h. There should be no sample lost during the retrieving operations.
i. The sample should be easy to remove from instrument once it is aboard ship.

In addition to the above criteria there are other factors which must be considered in the design in order to reduce disturbance and shortening of the sample. Hvorslev (1949) presents a complete analysis of the forces involved and deformations associated with coring, and recommends that

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sediment samplers conform to certain minimal dimensions in order to produce the least disturbance. These parameters are presented in TABLE I and FIGURE 1, and the design recommendations for gravity corers, are presented in TABLE II (Richards, 1966).

Core Barrel

The core barrel is used to collect the sediment sample, either within the barrel itself or in a core liner which fits inside the barrel. Shape, length, and diameter are the major factors involved in designing the core barrel. In considering the shape, which could be either cylindrical, square, or triangular, it might be appropriate to compare the advantages of each. A square or triangular barrel has the following advantages:

a. Higher flextural strength in the direction of applied stress when coring.

TABLE I

PRINCIPLE DIMENSIONS OF SAMPLERS

AREA RATIO

$$C_a = \frac{D_w^2 - D_e^2}{D_e^2} \times 100 \approx \frac{\text{Vol. of displaced sediment}}{\text{Volume of sample}}$$

INSIDE CLEARANCE RATIO

$$C_i = \frac{D_s - D_e}{D_e} \times 100 \quad \text{(Controls inside friction)}$$

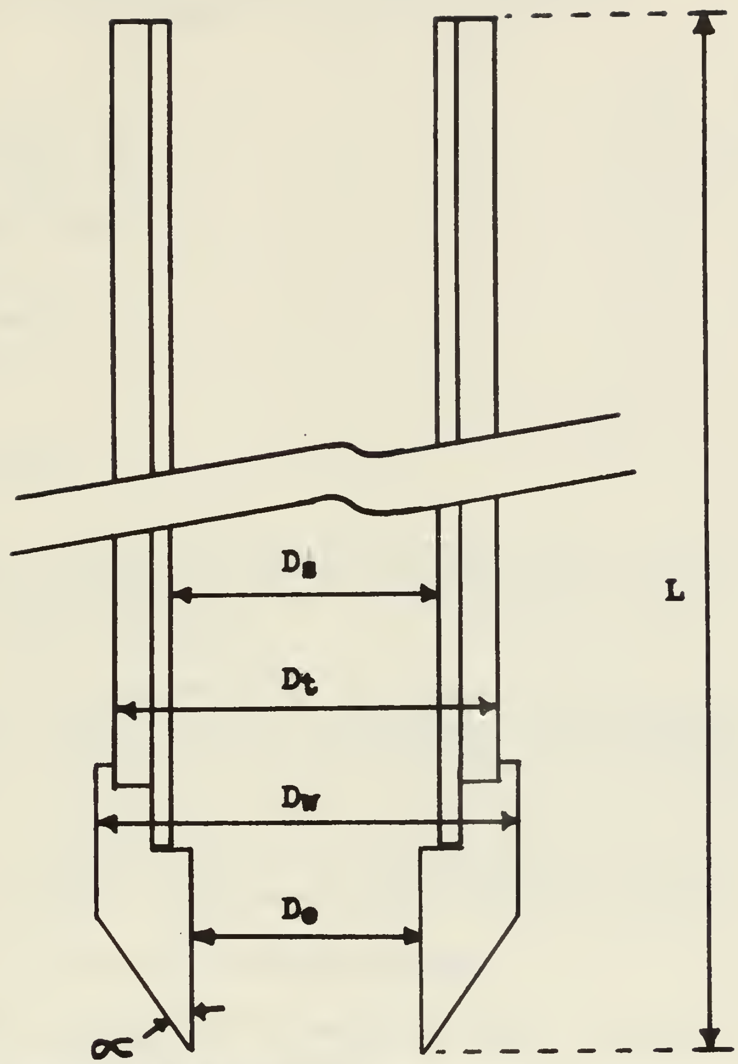
OUTSIDE CLEARANCE RATIO

$$C_o = \frac{D_w - D_t}{D_t} \times 100 \quad \text{(Controls outside friction)}$$

SAFE LENGTH TO DIAMETER RATIO

$$\frac{L_s}{D_s} \quad \text{(Controls maximum length of core that may be disturbed)}$$

See FIGURE 1 for definition of symbols



L maximum sampling length
D_s inside diameter of the barrel
D_t outside diameter of the barrel
D_w outside diameter of the cutter
D_e inside diameter of the cutter
α cutter angle

FIGURE 1

PRINCIPLE DIMENSIONS OF SAMPLERS

TABLE II

MINIMUM REQUIREMENTS FOR LEAST SAMPLING DISTURBANCE IN GRAVITY CORERS

Area Raio, C_a	<10	(note 1)
Inside Clearance Ratio, C_i	0.75 to 1.5	
Outside Clearance Ratio, C_o	0 to 3	
Safe Length-Diameter Ratio, L_s/D_s	<20	(note 1)
Cutting-edge Angle	$<5^o$	(note 2)
Minimum Inside Diameter	2 in.	
Check-valve Diameter	$\geq D_e$	
Core Retainer		
Continuous Drive Stroke		

Note 1 - Greater area ratios and safe length-diameter ratios can be tolerated when the cutting edge has a very small angle of taper.

Note 2 - For use in hard sediment, the angle of taper should be less than 20^o and it is advisable to in crease the angle to 30^o close to the cutting edge to avoid damage.

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b. More favorable shape for studying sediment structures, for it slices the sediment in a flat vertical plane.

The cylindrical corer has the following advantages:

a. Standard tubing for the barrel and liner is easier to find in cylindrical shapes.
b. Core retainers for cylindrical tubes have been designed to be closed in a single plane of motion while the square corer has had no such success.
c. The check-valve assembly at the upper end of the corer is easier to design for a cylindrical corer. A square corer usually has flap valves which seal poorly.

The diameter of the barrel depends on the purpose for which the sample is to be used. Cores of less than a 3-inch diameter are adequate for many types of sediment analysis, however the volume of sample obtained over a narrow length interval is frequently not sufficient for such purposes as radiocarbon dating, organic geochemistry, or for analyses which require a repetition of a particular test for statistical studies.

The length of the core barrel is in effect determined by its diameter. Hvorslev recommends a maximum safe length (L_s) of 5 to 20 times the inside diameter of the corer depending on the cohesiveness of the soil. This value is exceeded, however, in many corers in present use. Greater values of L_s can be tolerated without disturbing the sample, if the speed of penetration of the corer is high or if excessive inside clearance ratios are used (Hvorslev, 1949).

Core Cutter

The purpose of the core cutter is to reduce the wall thickness of the core barrel by tapering to a sharp cutting edge so as to more easily penetrate the sediment. A core cutter can simply be the sharpening of the edges of the lower end of the core barrel, or it can be a separate unit. The cutter is usually made to have a greater wall thickness than the core barrel and liner in order to conform to optimum inside and outside clearance ratios. Early efforts in the construction of core cutters consisted of a shoe which screwed on to the lower end of the core barrel, providing a sturdy edge with a more definite outside diameter and inside clearance than obtainable by sharpening the core barrel. A detachable core cutter is more advantageous, primarily because the core cutter is usually removed in order to extrude the sediment sample or remove the liner, and secondarily because it may become damaged during use and require replacement.

The standard methods of attaching a core cutter to the barrel are either by a threaded joint or through use of set screws. Neither method is completely satisfactory. Threaded joints tend to be stripped, thereby making it difficult to place and remove the cutter. Set screws are difficult and frustrating to handle on deck, particularly when the instrument is covered with sediment, and they tend to be misplaced and lost.

The optimum angle of taper of the cutting edge varies depending on the type of sediment being sampled. For very fine sediments an angle of taper of 5° is recommended (Kallstenius, 1958). For coarse sediments the angle of taper should be less than 20° but the bottom edge may be tapered to an even larger angle to avoid its breaking or chipping upon striking the bottom (Hvorslev, 1949).

Core Retainer

The core retainer is used to prevent loss of the sample while retrieving the corer. Core retainers should be designed so that there is a minimum disturbance to the sample as it enters the coring tube, and so that it forms a perfect block to any sediment which might escape from the bottom of the coring tube during retrieval. These requirements are difficult to fulfill and still maintain optimum inside and outside clearance ratios, in that the retainer should be smooth and continuous on the interior of the sampler and should have no protruding edges or unfilled recesses on either the inside or outside of the corer when in an open position.

A core retainer may not be necessary in some small diameter corers having an efficient seal at the upper end, and in fact is not desirable because it usually requires an increase in both wall thickness and area ratio of the sampler. In larger diameter corers a core retainer is usually a necessity regardless of how good the upper seal may be, because of the possible loss of the sample caused by the increased weight of the sediment, or shocks received by the corer during retrieval.

Vent and Check Valve

The purpose of the vent and check valve is to allow water to flow out of the upper end of the corer as it penetrates the sediment, and then to seal the upper end during retrieval so that the sampler is neither washed

out nor disturbed. The opening of this valve should be greater than the inside diameter of the core barrel in order to avoid a hydrostatic pressure buildup above the core should the water contained in the tube not exit as fast as the core enters.

The sealing action of the valve should be as complete as possible, but has been a difficulty in the design of coring devices. Rubber material used as valve seats or gaskets is open to question because of its behavior under high hydrostatic pressures. Spring loaded valves do provide good seating, but often develop a pressure buildup.

Weights

The weights used on the corer are to increase the penetration into the sediment. Optimum weight used depends both on the size of the corer and the type of sediment. The weights are normally attached above the core barrel, but as far down as possible in order that the center of gravity be low. Interlocking ingots of lead or cast iron are normally used, but may come loose during handling received by the corer in its operation.

Shroud

The shroud, when used, is to orient the corer vertically prior to its penetration into the sediment. The stability or instability of the corer as observed in free fall experiments should determine the need for such a stabilizing mechanism (Burns, 1966). It should be noted that severe shortening of cores and associated disturbances occur if the corer is not vertically oriented prior to penetration.

CHAPTER III

THE "MONO" GRAVITY CORER

The design of the corer was arrived at after nine months of investigation including a review of all available literature concerning coring devices and factors associated with coring, discussions with specialists in the field of coring, and correspondence with companies, federal agencies, and educational institutions involved in building and testing corers. The U.S. Naval Oceanographic Office provided much useful information on the subject of coring and tests conducted by them on various materials and components used in the manufacturing of corers. The discussions with Dr. E. L. Hamilton and Dr. R. F. Dill of the Navy Electronic Laboratory in San Diego, California, Mr. N. F. Marshall of Scripps Institute of Oceanography in LaJolla, California, and Mr. A. L. Inderbitzen of Lockheed Aircraft Corporation had considerable influence upon the final design for the instrument.

General Description

The "MONO" corer is a large-diameter general purpose gravity coring device (Fig.2 and 3). Many of the shortcomings of existing corers as well as the design considerations presented earlier were taken into account in its design. The corer consists of the following eight basic components:

a. core cutter
b. core retainer
c. core barrel
d. core liner
e. coupling section
f. weightstand
g. ball-check valve
h. ball-check valve housing unit

The overall characteristics of the corer are given in TABLE III.

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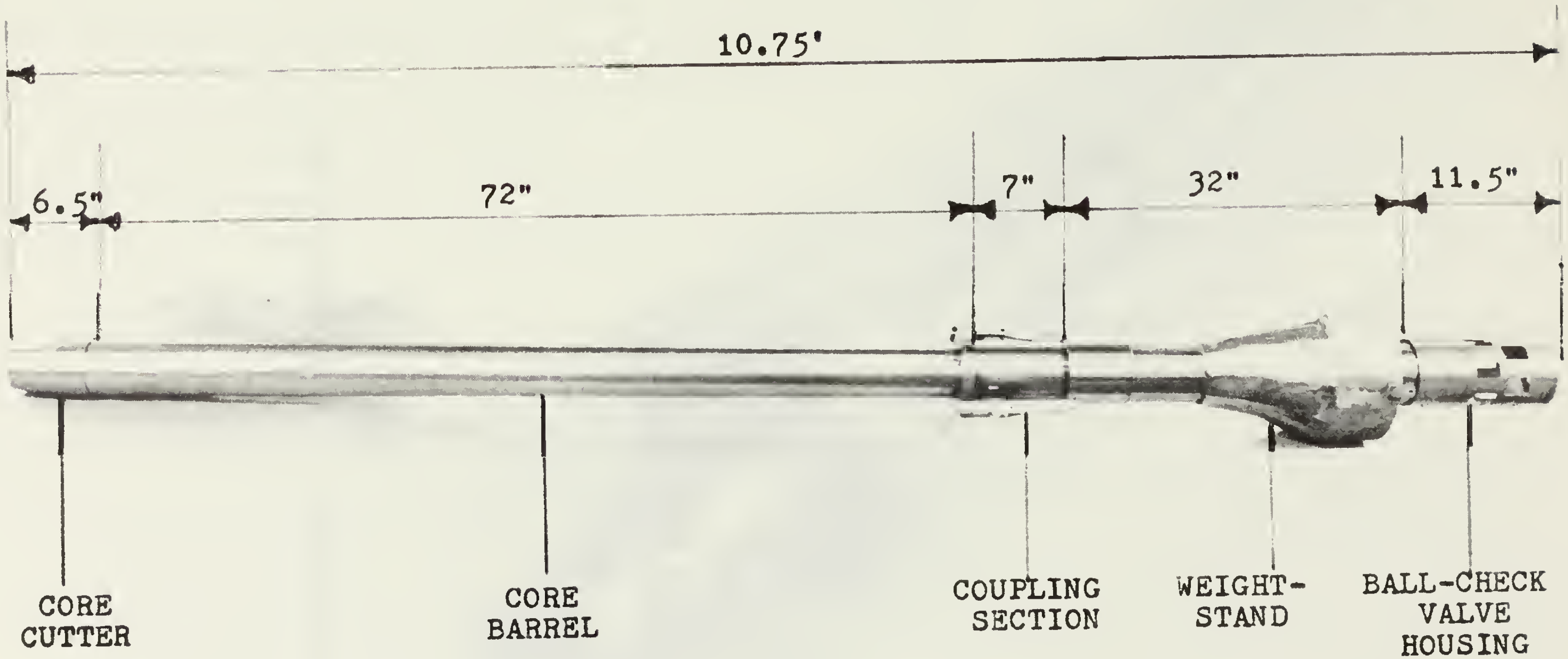

FIGURE 2

THE "MONO" GRAVITY CORER

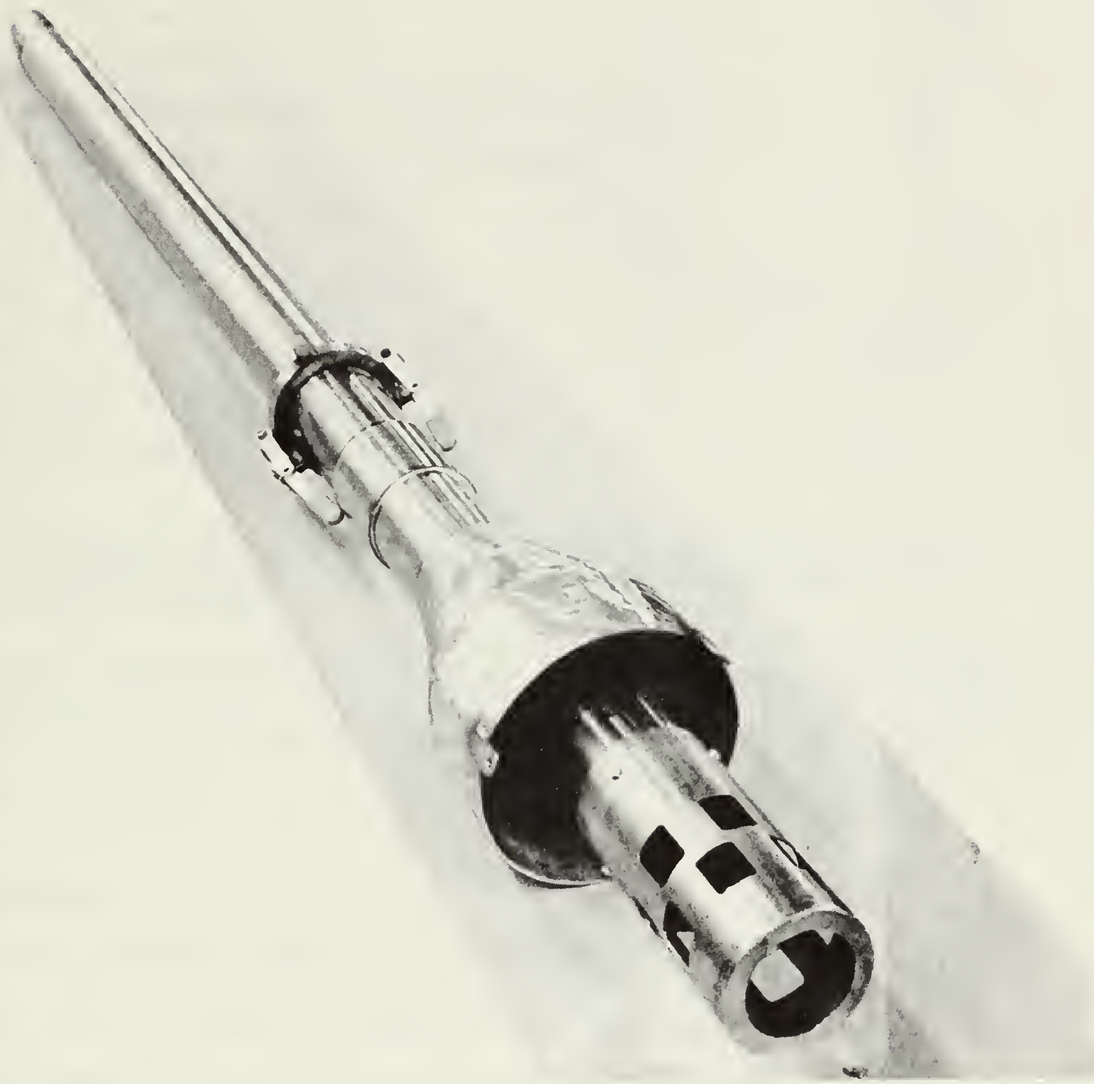

FIGURE 3

THE COMPLETE UNIT, VIEWED FROM ABOVE

TABLE III

OVERALL CHARACTERISTICS OF THE "MONO" CORER

Area Ratio, C_a	36.3*
Inside Clearance Ratio, C_i	1.52
Outside Clearance Ratio, C_o	2.2
Safe Length-diameter Ratio, L_s/D_s	18
Cutting Edge Angle (soft sediment model)	5^o
Minimum Inside Diameter, D_s or D_e	3.94 in
Check Valve Diameter	4.25 in
Overall Length	10.75 ft
Weight	205 lb
Spring Leaf Type Core Retainer	
Continuous Gravity Drive Stroke	

*This area ratio exceeds that recommended in TABLE II, but is accepted because of the sharp angle of the core cutter. See note 1 in TABLE II.

The corer was constructed by the Machine Shop at the Naval Postgraduate School during the period from early September to October 31, 1968.

Core Barrel

The core barrel (Fig. 4) is a cylindrical section of stainless steel tubing 6.5 ft in length, modified at its upper and lower ends. The outside diameter of the pipe is 4.5 inches with an inside diameter of 4.25 inches. The upper end of the barrel contains a ring-shaped bushing with four hooks spaced 90^o apart, which is welded to the barrel six inches from the upper end. Two of these hooks are used in connecting the barrel to the upper section of the corer by means of the quick-action clamps attached to the coupling section (Fig. 5). The other two hooks are used for connecting safety lines aboard ship, to prevent accidental loss of the barrel when it is removed from the upper section. The quick-action clamps

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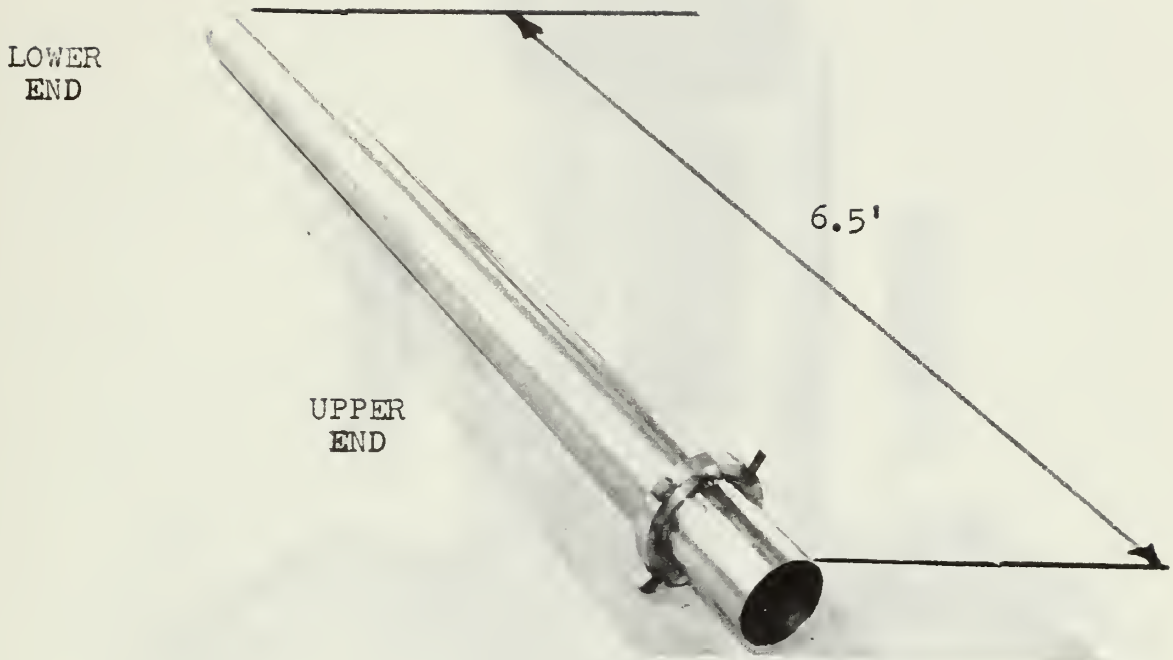

FIGURE 4

THE CORE BARREL

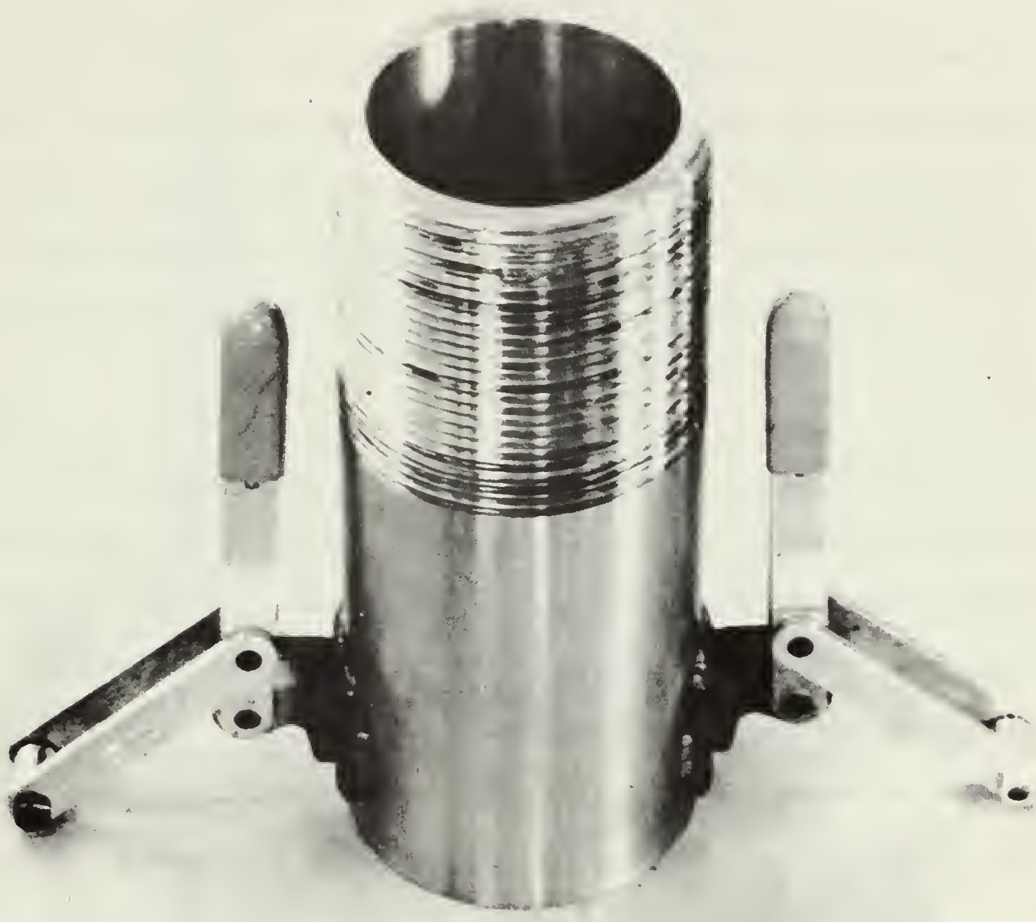

FIGURE 5

THE COUPLING SECTION SHOWING THE QUICK-ACTION CLAMPS

greatly facilitate removal of the core barrel, it not being necessary to work with the entire corer in order to remove a sample. The heavier bulky section of the corer remains on the wire and is ready for further use as soon as the barrel is replaced.

The modification to the lower end of the core barrel (Fig. 6 and 7) consists of a 3/8-inch wide eccentric groove around one-half the perimeter of the barrel, 1-5/8 inches from the lower end, and a machined flat extending from the edge of the barrel to the groove. This modification is to provide a quick and easy method of attaching the core cutter.

Core Cutter

Two stainless steel core cutters were constructed, one for use in soft sediment and the other for use in hard sediment. The soft sediment model (Fig. 8) is 6.5 inches long and has a 5^{o} taper to the cutting edge. The hard sediment model (Fig. 9) is 3.05 inches long and has a dual taper to the cutting edge. The lower 0.3 inches has a 30^{o} taper and the upper 0.5 inches of the cutting edge has a 19^{o} taper. The 30^{o} taper on the lower portion is to minimize the possibility of chipping the cutting edge in hard sediment.

The core cutters have two ridges machined on the inside wall (Fig. 10). The lower ridge supports the base of the core retainer while the upper ridge forms a seat for the core barrel.

A quick and easy method of attaching a core cutter to a core barrel was devised by R. P. Willis (1965) which eliminates the use of threaded joints or set screws. A slight modification of this method has been used here. A hole was drilled through the side wall of the core cutter so that when the barrel was seated against the upper ridge, the hole lined up with the eccentric groove in the barrel. A 3/8 inch metal dowel, beveled on

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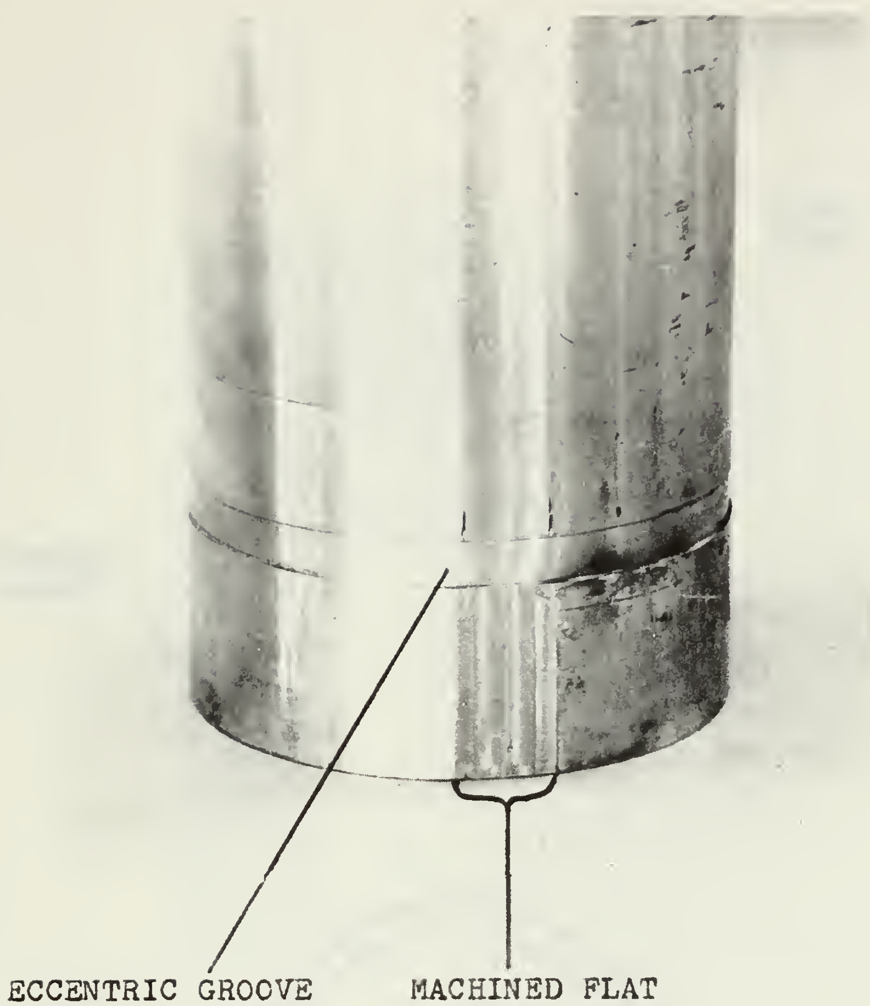


FIGURE 6

CLOSE-UP VIEW OF THE MODIFICATION TO THE LOWER END OF THE CORE BARREL, CONSISTING OF AN ECCENTRIC GROOVE AND MACHINED FLAT

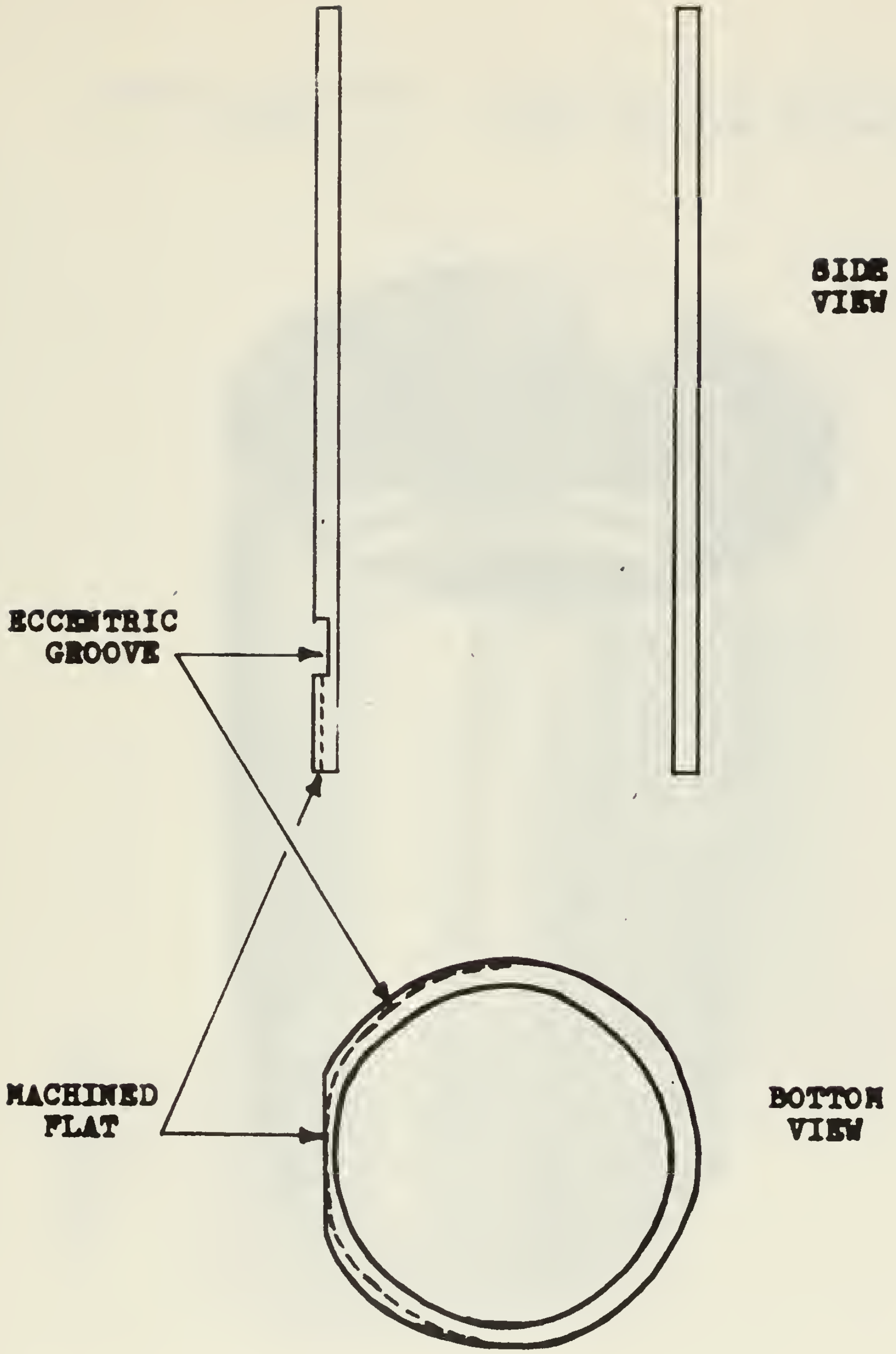


FIGURE 7

DETAILED SIDE VIEW OF THE LOWER END OF THE
CORE BARREL SHOWING MACHINING
OF GROOVE AND FLAT

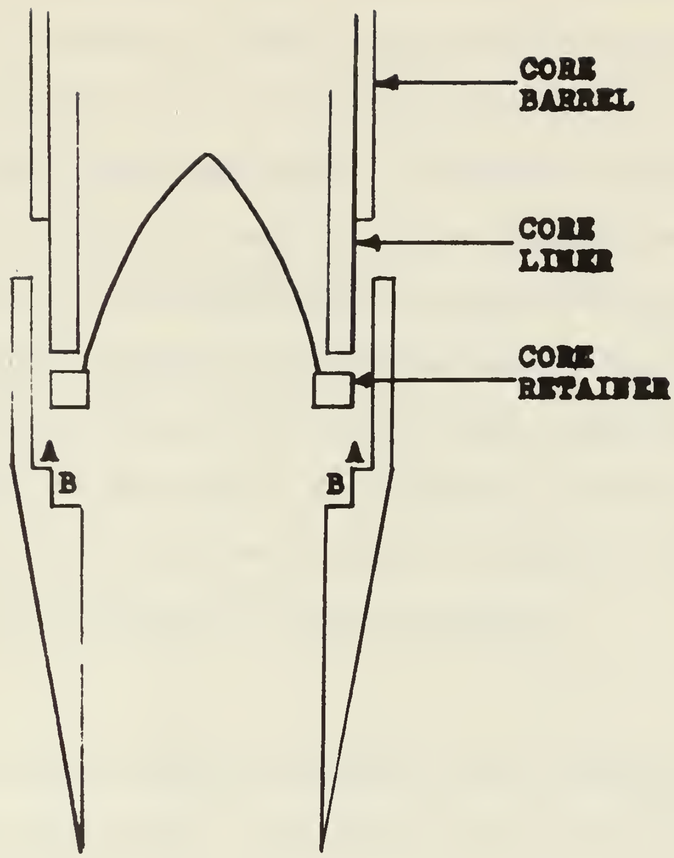
INWARDLY PROTRUDING DOWEL (Note the flat bevel on the lower portion of the dowel)

FIGURE 8

THE SOFT SEDIMENT CORE CUTTER

FIGURE 9

THE HARD SEDIMENT CORE CUTTER WITH THE CORE RETAINER IN PLACE



A - CORE BARREL RESTS AGAINST THIS RIDGE

B - CORE RETAINER AND LINER REST AGAINST THIS RIDGE

FIGURE 10

CROSS SECTION OF THE CORE CUTTER SHOWING THE TWO INSIDE RIDGES

its lower edge, was inserted in the hole and was welded so that it protruded 1/32-inch inside the inner wall of the core cutter. To place the core cutter on the barrel, the dowel is lined up with the flattened portion of the barrel's lower end and the cutter is pushed upward until the barrel seats against the upper ridge inside the cutter. At this point the beveled edge of the dowel is lined up with the lower lip of the eccentric groove on the barrel. The cutter is then rotated until it is tight in the groove. The eccentricity of the groove provides the tightening action. The core cutter is thus locked in place, being prevented from moving upward by the core barrel seating against the upper ridge, and downward by the dowel resting against the lower lip of the eccentric groove. Removal of the core cutter is accomplished by reversing the above procedure.

Core Retainer

The core retainer is of the standard spring-leaf type consisting of a brass base and stainless steel leaves. The leaves were cut from 0.01 inch stainless steel sheeting and were silver soldered to the base. Future core retainers will be made solely of stainless steel. The core retainer fits into the lower groove of the core cutter.

Core Liner

The plastic core liner is 6.5 ft long and has an outside diameter of 4.25 inches and an inside diameter of 4.0 inches. It fits inside the core barrel with its lower end resting on the base of the core retainer when the cutter and retainer are attached to the barrel. The upper edges of the barrel and the liner seat against a ridge inside the coupling section, thus preventing any vertical movement of the liner.

Coupling Section

The coupling section (Fig.5 and 11) is a one foot long stainless steel pipe upon which are mounted the two quick-action clamps used to attach the core barrel to the upper section of the corer. The upper six inches of the core barrel fit into the lower end of the coupling section and the clamps lock the barrel in place.

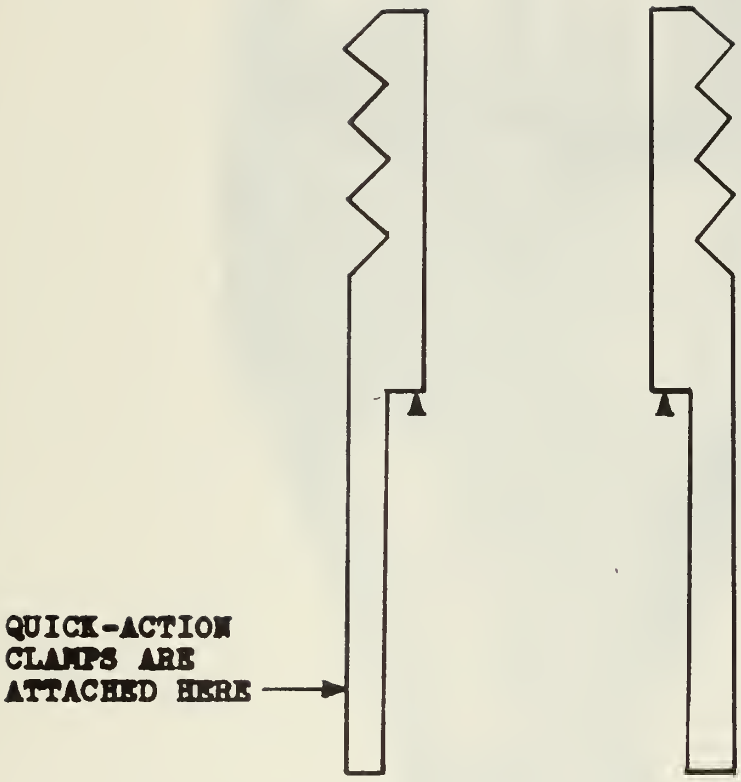
The threaded upper portion of this section forms the connection to the weightstand. The coupling section is made as a separate, removeable unit in order to facilitate repairs to, or replacement of the clamps when necessary.

Weightstand

The weightstand is constructed from two pieces of stainless steel piping having different diameters placed one inside the other (Fig. 12). The inner pipe is 32 inches long with an inside diameter of five inches. The lower portion is threaded to receive the coupling section, and the upper portion is fitted with an inside bushing and valve seat. The bushing is pressed into the inside of the pipe at a point one-fourth inch from the upper end and provides a base for the valve seat. The inside diameter of the bushing is one-half inch greater than the inside diameter of the core liner, thereby allowing a greater volume flow of water through the upper section of the corer than through the coring tube.

The valve seat is machined from a piece of solid nylon stock and is pressed and glued into the ridge formed by the upper face of the bushing and the side of the pipe.

The outer section of the weightstand consists of a 20-inch length of pipe, with a 13-inch inside diameter, modified by "orange peeling" to fit the inside pipe and then welded to it. This provides a void between the



A - UPPER EDGE OF THE CORE BARREL AND THE CORE LINER RESTS AGAINST THIS SURFACE

FIGURE 11

CROSS SECTION OF THE COUPLING SECTION

FIGURE 12

THE WEIGHTSTAND SHOWING THE BALL-CHECK VALVE SEAT

two sections of pipe which can be filled with lead weight, and has the advantage of giving the weightstand a streamlined shape, thus offering less resistance to corer passage through the water. The weight consists of 100 pounds of lead poured into the lower section of the void up to the point where the outer pipe reaches its full diameter. There is sufficient volume for 200 pounds of additional weight in the upper portion of the void, but this weight was omitted pending field tests.

Three padeyes spaced 120^{o} apart are welded to the upper edge of the outer pipe, and serve as the connection points between the corer and the oceanographic wire. This connection has been made at the sturdiest portion of the corer instead of at the top. In addition, the wide diameter of the outer pipe spreads the three connecting chains into a tripodal shape and thus gives the corer greater balance and stability as it is suspended from the wire.

Ball-check Valve Housing Unit

The uppermost section of the corer is the ball-check valve housing unit (Fig. 13). It consists of an 11.5 inch section of stainless steel pipe with water vent ports cut around its periphery. This unit is attached to the top of the weightstand by four bolts, and houses a hollow aluminum sphere, five inches in diameter. The sphere weighs 1.5 pounds and seats on the nylon valve seat located in the upper portion of the weightstand (Fig. 14). The inside surfaces of the housing unit are covered with a soft rubber lining to prevent scratching or denting the ball.

The operation of the ball-check valve can be divided into two phases, the descent and the ascent of the corer. As the corer is lowered, the water flowing through the barrel forces the ball against the top of the housing unit. With the ball in this position, the water vent ports are

FIGURE 13

THE BALL-CHECK VALVE HOUSING UNIT

FIGURE 14

THE WEIGHTSTAND AND THE SEATED BALL VALVE

open, thereby allowing the water to flow freely from the corer with no buildup of pressure above the core during penetration into the sediment. The area of these ports is much greater than the cross sectional area of the coring tube.

Prior to withdrawal of the corer, the ball falls to the nylon valve seat and forms a seal. As the corer ascends, water flows in through the top of the housing unit and out through the vent ports, thus causing a pressure increase above the ball, which further aids in the seating.

<u>Summary</u>

The corer was designed in an attempt to alleviate some of the problems encountered with other gravity coring devices in use today, by combining favorable features of the existing instruments with original ideas. The final design, conforming to the design limitations presented earlier, has the following characteristics:

- a. The only working parts on the corer are the two quick action clamps.
- b. The material used is corrosion resistant.
- c. The instrument is sturdy and is able to withstand repeated rough handling.
- d. The section of the corer which is brought on deck is not difficult to handle and can be carried by one man.
- e. The weight of the instrument is sufficient to allow the required penetration into soft sediment.
- f. The sample disturbance during penetration and withdrawal is kept to a minimum by remaining within the optimum inside and outside clearance ratios.
- g. The sample is easily removed from the corer aboard ship by removing the core liner.

In addition, the unique features of the corer include:

- a. A quick method of attaching the core cutter to the core barrel.
- b. Quick-action clamps used to attach the lower and upper sections of the corer, thus requiring only the lighter, lower portion of the instrument to be handled on deck.
- c. A streamlined weightstand, which offers less drag to the corer as it falls through the water and which encloses the weight, thereby preventing its loss.

[illegible]

d. A water vent assembly which allows the flow of a greater volume of water than that which flows through the coring tube as it penetrates into the sediment.

CHAPTER IV

TESTING OPERATIONS AND RESULTS

The corer was tested during November 1968 in the waters of Monterey Bay using the 63-ft oceanographic research vessel of the Naval Postgraduate School. This ship is equipped with an electro-hydraulic hydrographic winch using 3/8 inch, 7x7 plow steel wire. The initial testing was done on 6 November 1968 in the shallow portion of the bay, and although no cores were obtained, the operation of the corer proved to be satisfactory. An operational problem encountered was that the A-frame over which the oceanographic wire pays out is only 8 ft above the water surface. When the upper section of the corer is attached to the wire, it barely clears the water (Fig. 15), thereby making it impossible to insert the core barrel into the coupling section. In order to get the upper section of the corer to a level which permitted easy insertion of the barrel, the entire A-frame was raised until the coupling section rested on a Nansen Bottle rack located on deck (Fig. 16). In this position the core barrel could be inserted into the upper section, with the entire corer being clear of the water (Fig. 17 and 18). The A-frame was than lowered and the coring operation conducted (Fig. 19 and 20).

Testing Operations

A shallow depth was selected for the initial testing, in the event that the corer or any of its components were lost. Fifteen test drops were made in water ranging from 25 to 40 ft in depth. The corer appeared to function properly, but no cores were obtained. In view of the texture of the sediment in this shallow portion of the bay, this is understandable.

FIGURE 15

UPPER SECTION OF THE CORER SUSPENDED FROM THE A-FRAME, IN THE NORMAL OPERATING POSITION

FIGURE 16

UPPER SECTION OF THE CORER SUSPENDED FROM THE RAISED A-FRAME AND RESTING ON A NANSEN BOTTLE RACK

FIGURE 17

ENTIRE UNIT SUSPENDED FROM THE A-FRAME, READY TO BE LOWERED INTO THE WATER

FIGURE 18

CLOSE-UP VIEW OF CORER WITH BARREL ATTACHED, READY TO BE LOWERED INTO THE WATER

FIGURE 19

THE A-FRAME LOWERED INTO ITS NORMAL POSITION, WITH THE CORER SUSPENDED FROM IT, READY TO BEGIN CORING

FIGURE 20

CLOSE-UP VIEW OF THE CORER AS IT IS LOWERED

Testing was resumed on 15 November at a position 14,000 yards north of the entrance to Monterey harbor. The depth of water at this station is about 300 ft. The corer was lowered to various heights above the bottom ranging from 20 to 60 ft and was then allowed to fall to the bottom at the rate of 125 ft/min. The corer was then raised, the barrel removed, and the core extruded. The quick-action clamps operated very easily and made removal of the barrel a fast and efficient operation, requiring less than $\frac{1}{2}$ min to get the unit on deck. The removal of the core cutter was also simple and fast.

Results Obtained from Coring Operations

The recovery ratios defined in TABLE IV and FIGURE 21 were measured during the coring operations. These ratios can be a good indication of corer performance because they are directly related to sample disturbance. The recovery of a length of sample which is significantly less than the penetration of the sampler into the soil, usually results in disturbance to the sample.

TABLE IV

RECOVERY RATIOS

L = length of the sample before withdrawal of the corer
L_g = distance from the top of the sample to the cutting edge after withdrawal, irrespective of whether the lower portion of the sample is lost.
L_n = distance from the top to the bottom of the sample
H = total depth of penetration

See FIGURE 21 for definition of symbols

Total Recovery Ratio = $L/H \times 100$
Gross Recovery Ratio = $L_g/H \times 100$
Net Recovery Ratio = $L_n/H \times 100$

It should be noted that in gravity corers the Total Recovery Ratio and the Gross Recovery Ratio are essentially the same.

The recovery ratios obtained during testing operations are presented in TABLE V.

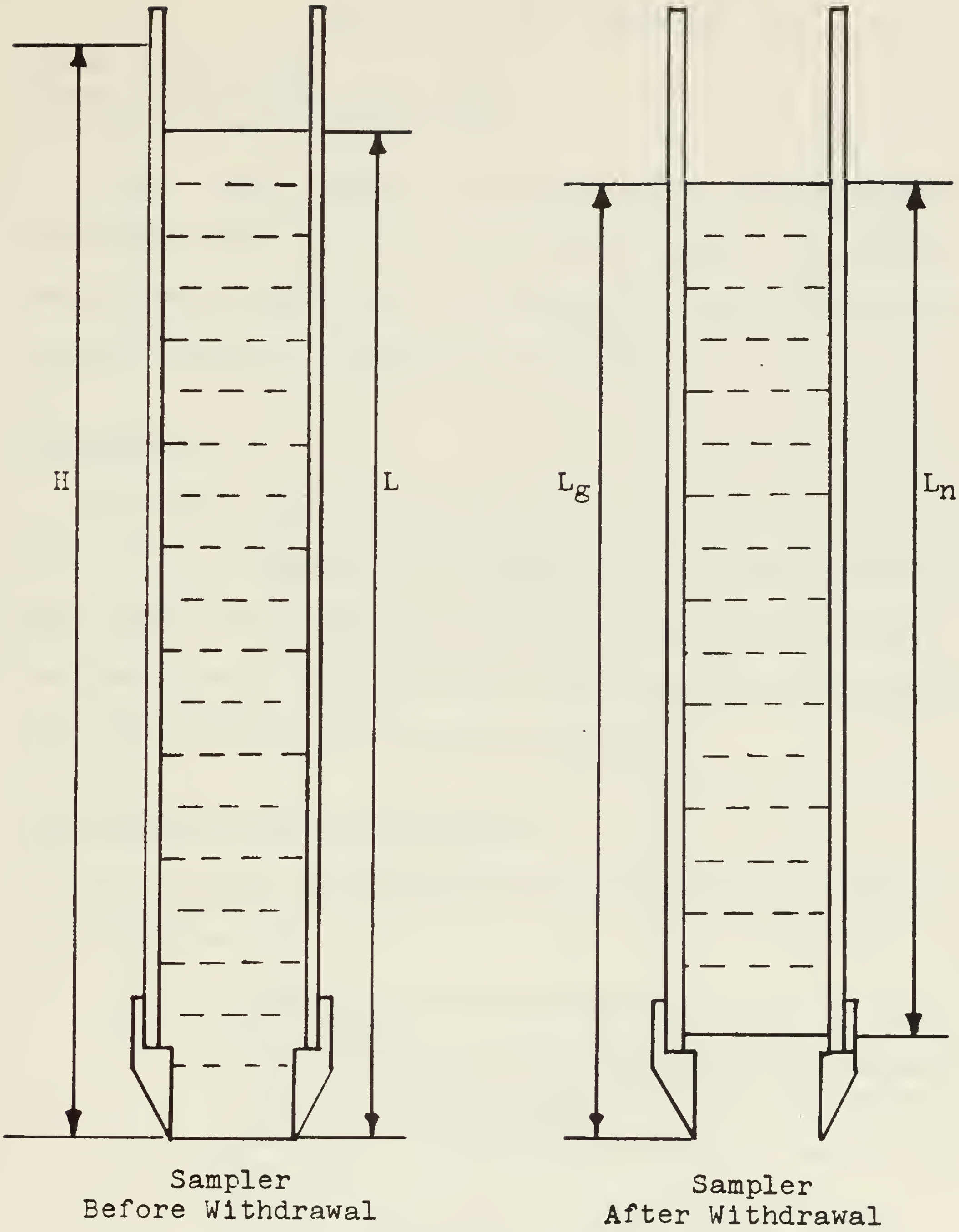


FIGURE 21

PRINCIPLE DIMENSIONS FOR COMPUTING
RECOVERY RATIOS

TABLE V

RESULTS OF CORING OPERATIONS

Total Recovery Ratio, L/H = 99.0%
Gross Recovery Ratio, L_g/H = 99.0%
Net Recovery Ratio, L_n/H = 94.2%

These figures represent an average of six cores, and in no case did they vary by more than 1% from one core to another. The high recovery ratios indicate that there is no shortening of the cores and subsequent analyses showed no deformation of the sample.

Conclusions

The unique features of the corer have proven useful in actual operations. The efficiency of the operation has been increased due to the easy removal and replacement of the core barrel and core cutter. The measured recovery ratios attest to the suitability of the streamlined weightstand and the ball check valve assembly.

Recommendations for Future Research

The following recommendations for future research associated with the corer are presented:

a. Determine the optimum weight for use in different types of sediment.
b. Attach a longer barrel and determine the maximum sediment thickness for which this corer can be used without serious distortion of the sample.
c. Develop a tripping assembly and test freefall operation of the corer.
d. Determine the need for a stabilizing mechanism.
e. Develop a method for positively sealing the ball-check valve during the ascent of the corer. Associated with this, test various materials under normal operational pressures, to see which is best suited for use as a valve seat.

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13. ABSTRACT

Many gravity corers in use today exhibit inherent problems and shortcomings associated with their design. The "MONO" corer is a wide diameter, general purpose, gravity coring tool designed to help alleviate some of these shortcomings. It incorporates several unique features so as to enable coring operations to be carried out with increased reliability and efficiency. Among these features are:

a. A quick method of attaching the core cutter to the core barrel.
b. Quick-action clamps used to attach the lower and upper sections of the corer.
c. A streamlined weightstand which encloses the weight and streamlines the corer, thus offering less drag.
d. A large-area water vent assembly which prevents a pressure buildup above the core.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Corer						
Gravity Corer						
Gravity Coring Instrument						
Gravity Coring Tool						
Sediment Sampler						
Wide-Diameter Corer						
Multi-Purpose Corer						
Sediment Corer						